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APPLICATION
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For: CALIPER BODY AND METHOD OF
MANUFACTURING CALIPER BODY OF
VEHICULAR DISK BRAKE

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**CALIPER BODY AND
METHOD OF MANUFACTURING CALIPER BODY OF VEHICULAR DISC BRAKE**

BACKGROUND OF THE INVENTION

5 The present invention relates to a method of manufacturing caliper bodies of vehicular disc brakes and to a caliper body.

 A vehicular disc brake is so arranged as to obtain braking force by pressing a pair of frictional pads disposed opposite to each other with a disc rotor held therebetween to contact
10 respective disc surfaces.

 A typical vehicular disc brake is arranged so that braking force is obtained by pressing a pair of frictional pads disposed opposite to each other with a disc rotor held therebetween to contact respective disc surfaces. The caliper body of the disc
15 brake is designed to support the frictional pads in such a way as to be press-contact the disc rotor contains a piston for pressing the disc rotor under pressure.

 Generally, iron is used to make a caliper body of the sort mentioned above by casting. However, in recent years, there has
20 developed a demand for making caliper bodies of disc brakes more lightweight and this has resulted in studying the possibilities of manufacturing caliper bodies by using lighter aluminum or aluminum alloy in place of iron. The use of aluminum or aluminum alloy for manufacturing caliper bodies can contribute to
25 reducing their weight in comparison with the iron products.

[illegible]

20 It is an object of the present invention to provide a method
of manufacturing caliper bodies of vehicular disc brakes using
aluminum and aluminum alloy by casting method, particularly by
the gravity casting method to ensure that the caliper body having
desired rigidity and stable quality can be made to offer a highly
25 reliable product, whereby a yield rate as well as productivity

is made improvable and also provide the caliper body of a vehicular disc brake.

In order to accomplish the object above, the present invention is arranged as follows: a method of manufacturing a caliper body of a vehicular disc brake by the casting method, the caliper body being used for the vehicular disc brake wherein a pair of frictional pads are disposed opposite to each other with a disc rotor held therebetween, the caliper body having a cylinder disposed on one side of the disc rotor, a reaction pawl disposed on the other side of disc rotor, and a bridge for coupling the cylinder and the reaction pawl on the outer peripheral side of the disc rotor, is characterized in that a sprue is provided in the bottom portion of the cylinder, and that the caliper body is cast by a cavity with the side of molding the bottom portion of the cylinder disposed in the upper part of and in the vertical direction of the cavity and with the side of molding the reaction pawl disposed in the lower part of and in the vertical direction thereof. Thus, molten metal can sufficiently be run round in the cylinder and the reaction pawl, so that the caliper body of the vehicular disc brake securing sufficient rigidity is obtainable. In the method of manufacturing a caliper body of a vehicular disc brake, a gravity casting method may be used as the casting method.

The method of manufacturing the caliper body of the vehicular disc brake is characterized in that provided that the

side of molding the cylinder of the cavity is made an action chamber; the side of molding the reaction pawl and the bridge is made a reaction chamber; and the site of molding a thick-walled side between the cylinder and the bridge is made a central chamber, the ratio of volume of the central chamber to that of the reaction chamber (central chamber/reaction portion) is in the range of 0.6 to 1.25, and that the ratio of volume of the central chamber to that of the action chamber (central chamber/action portion) is in the range of 0.7 to 1.35.

10 By setting the ratio of volume of the central chamber to that of the reaction chamber in the range of 0.6 to 1.25, solidification starts from the reaction portion where the molten metal enters first after the injection of the molten metal is carried out. The solidification of the molten metal then progresses toward the central portion where the solidification is slow. Even though the volume of the reaction portion is reduced because of the solidification, the supply of the molten metal from the central portion where the solidification is slow can be continued due to the supply effect based on the ratio of volume, whereby it is considered that any sink mark is prevented from being produced in the reaction portion. Thus, the rigidity of the reaction portion of the caliper body is sufficiently secured.

25 By setting the ratio of volume of the central portion to that of the action portion to 0.7 - 1.35 whereby while the

solidification of the central portion is supplying the molten metal to the reaction portion to allow the molten metal to be continuously supplied from the action portion rather than from the central portion where the solidification is slow due to the
5 supply effect based on the ratio of volume. Thus, any sink mark is prevented from being produced in the reaction portion and the rigidity of the central portion of the caliper body is sufficiently secured.

With respect to the action portion, moreover, as the molten
10 metal is supplied via a gate by a feeding head, no sink mark is produced in the action portion to ensure that sufficient rigidity is secured in the action portion.

With the solidification mechanism above, by maintaining the volume ratio in the proper range and securing the continuous step
15 by step supply effect based on the volume ratio comprising the directional solidification in the cavity and the configuration of the cast instead of heretofore relying on the supply by the feeding head from such a gate, no sink mark is produced even by the caliper body of a complicated vehicular disc brake having
20 a great difference in the wall thickness ratio. Accordingly, a yield rate is improved and rigidity is sufficiently secured, which results in making a good-quality caliper body designed for the vehicular disc brake.

A caliper body of a vehicular disc brake to be made by the
25 casting method, the caliper body being used for the vehicular

disc brake wherein a pair of frictional pads disposed opposite to each other with a disc rotor held therebetween, the caliper body having a cylinder disposed on one side of the disc rotor, a reaction pawl disposed on the other side of disc rotor, and
5 a bridge for coupling the cylinder and the reaction pawl on the outer peripheral side of the disc rotor, is characterized in that the caliper body is cast by a cavity with the side of molding the bottom portion of the cylinder disposed in the upper part of and in the vertical direction of the cavity and with the side
10 of molding the reaction pawl disposed in the lower part of and in the vertical direction thereof. As molten metal is sufficiently run round in the cylinder and the reaction pawl, the caliper body of the vehicular disc brake is provided as a product that is free from a sink mark and has sufficient rigidity.
15 The caliper body may be made by a gravity casting method.

A caliper body of a vehicular disc brake to be made by the casting method, the caliper body being used for the vehicular disc brake wherein a pair of frictional pads disposed opposite to each other with a disc rotor held therebetween, the caliper
20 body having a cylinder disposed on one side of the disc rotor, a reaction pawl disposed on the other side of disc rotor, and a bridge for coupling the cylinder and the reaction pawl on the outer peripheral side of the disc rotor, is characterized in that a union hole in the bottom portion of the cylinder of the caliper
25 body is used as a sprue, and the caliper body is cast by a cavity

disposed with the union hole disposed in the upper part of and in the vertical direction of the cavity and with the reaction pawl disposed in the lower part of and in the vertical direction thereof. The caliper body of the vehicular disc brake is provided as a product having sufficient rigidity and as the union hole in the bottom portion of the cylinder is made the sprue, the processed sprue can directly be made the flange portion of the union hole. The caliper body may be made by a gravity casting method.

10 In the caliper body of the vehicular disc brake above, provided that the side of providing the cylinder is made an action chamber; the side of providing the reaction pawl and the bridge is made a reaction chamber; and the thick-walled connection between the cylinder and the bridge is made a central chamber, 15 the caliper body is characterized in that in the state of cast metal after casting but before being subjected to a cutting process, the ratio of volume of the central chamber to that of the reaction chamber (central chamber/reaction portion) is in the range of 0.6 to 1.25, and that the ratio of volume of the 20 central chamber to that of the action chamber (central chamber/action portion) is in the range of 0.7 to 1.35. Further, in the caliper body of the vehicular disc brake, provided that the side of providing the cylinder is made an action chamber; the side of providing the reaction pawl and the bridge is made 25 a reaction chamber; and the thick-walled connection between the

cylinder and the bridge is made a central chamber, the caliper body is characterized in that in the state of cast metal after casting and subjected to the cutting processing, the ratio of volume of the central chamber to that of the reaction chamber (central chamber/reaction portion) is in the range of 0.6 to 1.25, and that the ratio of volume of the central chamber to that of the action chamber (central chamber/action portion) is in the range of 0.7 to 1.35.

By setting the ratio of volume of the central chamber to that of the reaction chamber (central chamber/reaction portion) in the range of 0.6 to 1.25 and setting the ratio of volume of the central chamber to that of the action chamber (central chamber/action portion) in the range of 0.7 to 1.35, it is possible to secure the continuous step by step supply effect based on the volume ratio comprising the directional solidification in the cavity and the configuration of the cast instead of heretofore relying on the supply by the feeding head, no sink mark is produced even by the caliper body of a complicated vehicular disc brake having a great difference in the wall thickness ratio. Accordingly, a yield rate is improved and rigidity is sufficiently secured, which results in making a good-quality caliper body designed for the vehicular disc brake.

In the caliper body of the vehicular disc brake above, casting can be carried out by inserting the front end portion of a core into the cylinder hole and in this case, the molten

metal injected from the bottom portion side of the cylinder is introduced from the front end side of the core along the bridge and the reaction pawl side with the effect of improving the running efficiency of the molten metal and further providing a
5 caliper body having excellent rigidity.

In the caliper body of the vehicular disc brake above, moreover, a product using aluminum or aluminum alloy as a base material is utilizable effectively as what is light and provided with sufficient rigidity.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a plan view of a caliper body of a vehicular disc brake embodying the invention;

Fig. 2 shows an front view of the caliper body of the
15 vehicular disc brake embodying the invention;

Fig. 3 shows a sectional side view of the caliper body of the vehicular disc brake embodying the invention;

Fig. 4 shows a diagram explanatory of an arrangement of pressing frictional pads to contact a disc rotor;

Fig. 5 shows a diagram explanatory of a method of making
20 the caliper body of the vehicular disc brake;

Fig. 6 shows a diagram explanatory of the behavior of molten metal running round from a cylinder toward the side of a reaction pawl;

25 Fig. 7 shows a diagram explanatory of a state in which the

caliper body is divided into sections in order to measure the volume of each;

Fig. 8 shows a graph showing the measured results of each section of the caliper body after casting and before being
5 subjected to a cutting process;

Fig. 9 shows a graph showing the measured results of each section of the caliper body after casting and being subjected to the cutting process;

Fig. 10 shows a graph showing test results of the production
10 of sink marks on casts of caliper bodies with the values in the central chamber/reaction chamber as indexes; and

Fig. 11 shows a graph showing test results of the production of sink marks on casts of caliper bodies with the values in the central chamber/action chamber as indexes.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiment of the invention will now be described in detail with reference to the accompanying drawings.

Figs. 1, 2 and 3 are respectively a plan view, an elevational
20 view and a sectional side view showing the construction of the caliper body of a vehicular disc brake embodying the present invention. The caliper body 10 is made by the gravity casting method using aluminum. Figs. 1 - 3 show the casting that has been cast and then subjected to a cutting process.

25 The caliper body 10 substantially comprises a cylinder 20

for containing a piston, a reaction pawl 30 disposed opposite to the cylinder 20, and a bridge 40 for coupling the cylinder 20 and the reaction pawl 30.

5 A cylindrical cylinder hole 20a for containing the piston is formed in the cylinder 20. The reaction pawl 30 is a part for making the pressing force of the piston as a counter force act on frictional pads and formed in such a way that it is bent in a direction substantially perpendicular to the bridge 40 as shown in Fig. 3. A U-shaped cutout 32 in elevational view is
10 formed in the central portion of the reaction pawl 30, so that the pawl portion is extended laterally from the bridge 40 as shown in Fig. 2.

As shown in Fig. 3, the bridge 40 is a part for coupling and connecting the cylinder 20 and the reaction pawl 30 and is
15 as shown in Fig. 2 formed so as to curve in an arcuate form harmoniously with the outer peripheral diameter of a disc rotor.

As shown in Fig. 1, the bridge 40 is formed into a planar and substantially rectangular shape. Fig. 1 shows that as a whole the caliper body 10 is formed into a substantially lateral
20 symmetric shape with the cylinder 20 set in the substantially central position and is also formed so that its width may gradually be increased from the cylinder 20 up to the bridge 40.

Reference numerals 26 and 28 denote arm portions formed with insertion holes 26a and 28a into which bolts for supporting
25 brackets are inserted.

Fig. 4 is a diagram explanatory of a state in which the caliper body 10 according to this embodiment of the invention is used to form a disc brake 1. Reference numeral 12 denotes a disc rotor, and frictional pads 14 and 14 are disposed opposite
5 in position to each other as to hold the disc rotor 12 therebetween.

Reference numeral 14a denotes a frictional material; and 14b, a backplate. The frictional pads 14 are supported by the caliper body 10 so that they can be pressed to contact the respective rotor surfaces of the disc rotor 12 via a bracket (not shown).

10 Reference numeral 22 denotes a piston mounted in the cylinder 20; and 24, a union hole opened in the center of the bottom portion of the cylinder 20.

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A hydraulic circuit for braking communicates with the union hole 24 through which brake fluid is introduced into the cylinder
15 hole 20a. The cylinder 20 is disposed on side of the disc rotor 12, whereas the reaction pawl 30 is disposed on the other side of the disc rotor 12 facing the cylinder 20. Consequently, the generation of fluid pressure from a fluid generating means such as a master cylinder (not shown) causes the fluid pressure to
20 be introduced into the cylinder hole 20a. When the piston that has been moved forward presses the frictional pad 14 to contact the disc rotor 12, the pressing force of the piston 22 acts on the frictional pad 14 on the other side as counter force via the bridge 40 and the reaction pawl 30, thus pressing the frictional
25 pad 14 on the other side to contact the disc rotor 12. Thus,

the disc rotor 12 is clamped under pressure between both frictional pads 14 and 14 and this results in producing braking force.

As mentioned above, the caliper body 10 according to this embodiment of the invention is made by the gravity casting method using aluminum. As molten metal is not press-fitted into a mold under high pressure by the gravity casting method, it is necessary to determine a sprue and the configuration of each part in consideration of how the molten metal runs round in the mold in a case where what has a complicated configuration is produced.

Fig. 5 is a diagram explanatory of a process of making the caliper body 10 according to this embodiment of the invention by the gravity casting method using aluminum. This embodiment of the invention is characterized in that the cavity of a mold for use in molding the caliper body 10 is arranged so that the side of molding the bottom portion of the cylinder 20, that is, the union hole 24 is positioned in the vertically upper part of the cavity; the side of molding the reaction pawl 30 is in the lower part thereof; and the sprue is disposed in the union hole 24 as the bottom portion of the cylinder 20 whereby to inject the molten metal into the cavity. Reference numeral 42 denotes a core. The cylinder 20 is disposed in the substantially center of the bilateral direction and cylindrical with a hollow interior. The one side of the bridge 40 is opened and formed with the cutout on the side of the reaction pawl 30 to cover up these parts, and

the core 42 is formed into such a shape that these parts can be drawn downward.

As shown in Fig. 5, the cylinder 20 of the caliper body 10 is set to look upward and according to the casting method in which the molten metal is injected from the site where the union hole 24 is formed, the molten metal is laterally and uniformly injected into the mold because the site through which the molten metal is injected is in bilateral symmetry with respect to the sprue, so that the molten metal is uniformly injected as a whole. Since the molten metal is thus uniformly injected into the mold, the molten metal is allowed to run sufficiently up to the site where the lower-side reaction pawl 30, to say nothing of the cylinder 20, is molded, whereby it is possible to obtain the caliper body 10 that is stable in quality without a sink mark and has sufficient rigidity.

With attention riveted to the sprue portion, the formation of the sprue in the central portion of the edge face of the cylinder 20 is advantageous in that the flange portion of the union hole 24 is simply formable only by processing the sprue portion after the casting.

The use of the core 42 causes the molten metal injected from the sprue to run toward the disc running-in and running-out sides of the bridge 40 along the core 42 to ensure that the molten metal runs round toward the reaction pawls 30 laterally positioned, which makes the running efficiency of the molten metal

improvable.

Fig. 6 is a perspective view of the situation in which the molten metal runs round from the cylinder 20 to the side of the reaction pawl 30 in the case of the casting method shown in Fig.

5 5.

Thus, in the caliper body manufacturing method according to this embodiment of the invention, the manufacture of a cast of good quality by letting the molten metal run round effectively in the whole mold. When the caliper body is actually designed, however, as the molten metal is caused to run round suitably in the mold to make a product having desired rigidity, the volume of each portion of the caliper body needs to be determined properly. This is because the weight of molten metal to be injected into the mold affects the casting result when the gravity casting method is employed for casting purposes.

Fig. 7 is a diagram showing the caliper body 10 according to this embodiment of the invention which is actually sectioned at equal intervals from the cylinder 20 toward the reaction pawl 30 in order to measure the volume of each section. The meaning of dividing the caliper body 10 into sections from the cylinder 20 toward the reaction pawl 30 as shown in Fig. 7 is that by dividing the caliper body 10 in a direction perpendicular to the direction in which the molten metal is injected into the mold, the volume of the molten metal to be injected into the mold is taken into consideration.

Figs. 8 and 9 are graphs indicating the volume of each section when the caliper body 10 is divided equally into 28 sections as shown in Fig. 7. Fig. 8 refers to a state in which the caliper body 10 is taken out of the mold before being subjected to the cutting process; and Fig. 9, a state in which it has been subjected to the cutting process.

In the graphs of Figs. 8 and 9, the abscissa axis shows the position of each section when the caliper body 10 has been divided equally into sections and the ordinate axis shows the volume of each section. The pillar-like graphs in Figs. 8 and 9 show the volume in each group (the added-up volume of the sections in the relevant group) when the sections resulting from equally dividing the caliper body 10 are further divided into seven groups A - G.

Tables 1 and 2 show the volume of each section and the volume in each group. Table 1 refers to the volume in each group before the cutting process is performed and Table 2 refers to data after the cutting process is performed.

[Table 1]

Sections	2	3	4	5	6	7	8	9	10
Volume of the whole section (cm ³)	58.3			54.5				44.1	
Volume of section (cm ³)	9	27	22.3	22.3	11.1	10.8	10.3	9	8.6

11	12	13	14	15	16	17	18	19
			141.6					
8.5	8.5	9.5	11.5	23.3	29.3	28.4	26	23.1

20	21	22	23	24	25	26	27
63			39.7		34		20.5
24.1	19.6	19.3	19.7	20	17	17	

[Table 2]

Sections	2	3	4	5	6	7	8	9	10
Volume of the whole section (cm ³)	51.1			54.5				44.1	
Volume of section (cm ³)	7.2	21.6	22.3	22.3	11.1	10.8	10.3	9	8.6

11	12	13	14	15	16	17	18	19
			123.6					
8.5	8.5	9.5	11.5	19.7	25.7	24.8	22.4	19.5

20	21	22	23	24	25	26	27
48.9			36.1		34		20.5
17.2	16	15.7	16.1	20	17	17	

5 The division of the caliper body 10 into sections reveals that the volume of the section in the central portion of the caliper body 10 formed relatively thickly becomes greater. As the molten metal is injected from the top of the cavity as shown in Fig. 5 when the molten metal is injected into the mold, the

10 reason for the division of the caliper body 10 into the seven groups A - G is that it is meaningful to divide the caliper body 10 into sections in view of coherence of configuration when the

running efficiency of the molten metal is taken into consideration.

A, B and C groups correspond to the cylinder 20 of the caliper body 10 and equivalent to the upper position where the molten metal is injected in. As viewed from the direction of injecting the molten metal, D group is in the substantially central position of the mold and as shown in Figs. 8 and 9 the distribution of the volume is greatest. E, F and G groups are site having a relatively small volume and like the reaction pawl 30 where the direction of injecting the molten metal is bent, the sites develop a problem arising from the running of the molten metal.

When the profile of the caliper body 10, the distribution of volume of the sections A - G and the running of the molten metal in each section are taken into consideration, the quality of the cast is considered to be affected by the volume of each section in the case where the caliper body 10 is cast by the gravity casting method. Accordingly, the caliper body 10 was divided into three areas: A, B and C sections (the site of the cylinder 20); D section where the ratio of volume was greatest; and E, F and G sections (the site including the reaction pawl 30 and the bridge 40) of Fig. 7, products were examined to see whether they were good or bad with the ratios of volume as indexes.

Hereinafter, A, B and C sections are referred to as action portions acting on the frictional pads, and E, F and G sections are referred to as reaction portions. The central portion is

the thick-walled connecting portion D formed between the cylinder 20 and the bridge 40. Moreover, the sites where the action portion, the reaction portion and the central portion are molded in the cavity of the mold are called an action chamber, an reaction chamber and a central chamber, respectively.

Fig. 10 shows the results examined on the sink marks of cast products with the ratio of volume of the central portion to that of the action portion as an index. The values on the abscissa axis represent those which have resulted from dividing the volume of the central portion by that of the reaction portion.

According to the test results, no sink marks appear on the cast products when the values of (central portion/reaction portion) are in the range of 0.6 to 1.25, so that good products are obtainable. When the values of (central portion/reaction portion) are less than 0.6, the sink marks are seen to appear in the reaction portion and when the values of (central portion/reaction portion) are greater than 1.25, the sink marks appear in the central portion. Regarding the product before the cutting process shown in Fig. 8, the value of (central portion/reaction portion) is 0.9 and regarding the product after the cutting process shown in Fig. 9, the value of (central portion/reaction portion) is 0.82.

The relation of the ratio of volume of the central portion to that of the reaction portion, that is, while the ratio of volume of the central portion thereto is in the range of 0.6 to 1.25,

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solidification starts from the reaction portion (reaction chamber) where the molten metal enters first after the injection of the molten metal is carried out. The solidification of the molten metal then progresses toward the central portion where the solidification is slow. Even though the volume of the reaction portion is reduced because of the solidification, the supply of the molten metal from the central portion where the solidification is slow can be continued due to the supply effect based on the ratio of volume, whereby it is considered that any sink mark is prevented from being produced in the reaction portion. Thus, the rigidity of the reaction portion of the caliper body is sufficiently secured.

Fig. 11 shows the results examined on the sink marks of cast products with the ratio of volume of the central portion to that of the action portion as an index. The values on the abscissa axis represent those which have resulted from dividing the volume of the central portion by that of the action portion.

According to the test results, no sink marks appear on the cast products when the values of (central portion/action portion) are in the range of 0.7 to 1.35, so that good products are obtainable. When the values of (central portion/action portion) are less than 0.7, the sink marks are seen to appear in the action portion and when the values of (central portion/action portion) are greater than 1.35, the sink marks appear in the central portion. Regarding the product before the

cutting process shown in Fig. 8, the value of (central portion/action portion) is 1.04 and regarding the product after the cutting process shown in Fig. 9, the value of (central portion/action portion) is 1.03.

5 The relation between the central portion and the action portion, that is, the ratio of volume of the central portion to that of the action portion is set to 0.7 - 1.35 whereby while the solidification of the central portion is supplying the molten metal to the reaction portion to allow the molten metal to be
10 continuously supplied from the action portion rather than from the central portion where the solidification is slow due to the supply effect based on the ratio of volume. Thus, it is considered that any sink mark is prevented from being produced in the reaction portion and the rigidity of the central portion
15 of the caliper body is sufficiently secured.

With respect to the action portion, moreover, as the molten metal is supplied via a gate by a feeding head, no sink mark is produced in the action portion to ensure that sufficient rigidity is secured in the action portion.

20 In the case of manufacturing the caliper bodies of vehicular disc brakes particularly by the gravity casting method, as casting is not carried out by applying pressure to molten metal, the running efficiency and solidifying properties in the cavity of the mold are brought into question to make a good cast free
25 from the sink mark. When a product having a complicated

configuration and a great difference in the wall thickness ratio is cast, the supply of the molten metal by the effect of the feeding head and the setting of the volume ratio among the reaction, central and action portions properly make it possible
5 to provide the caliper body of a vehicular disc brake which does not produce a sink mark in each portion, offers a high yield rate and secures sufficient rigidity.

In the method of manufacturing the caliper body of the vehicular disc brake and the caliper body according to the
10 invention, the caliper body can surely be made as a product securing sufficient rigidity and as a good product having desired rigidity. In particular, by properly selecting the ratio of volume of the central portion to that of the reaction portion and the ratio of volume of the central portion to that of the
15 action portion, it is possible to provide a product having desired rigidity for certain without the problem of sink marks and the like. Moreover, the use of aluminum or aluminum alloy as a base material makes the caliper body lighter than before and the invention has the magnificent effect of providing the useful
20 caliper body of a vehicular disc brake having desired rigidity.

While there has been described in connection with the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is
25 aimed, therefore, to cover in the appended claim all such changes

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